Regional Operational Plan CF.2A.13.01

Operational Plan: Stock Assessment of Chinook Salmon in the Nushagak River Drainage, 2014

by

Charles Brazil,

Greg Buck,

Suzanne Maxwell,

and

Craig Schwanke

February 2014

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm
Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd
Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s
Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General	
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics	
all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN CF.2R.13.XX

OPERATIONAL PLAN: STOCK ASSESSMENT OF CHINOOK SALMON IN THE NUSHAGAK RIVER DRAINAGE, 2014

by

Charles Brazil, Greg Buck, Suzanne Maxwell and Craig Schwanke

Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage

Alaska Department of Fish and Game
Division of Commercial Fisheries, Publications Section
333 Raspberry Rd, Anchorage, Alaska, 99518
February 2014

The Regional Operational Plan Series was established in 2012 to archive and provide public access to operational plans for fisheries projects of the Divisions of Commercial Fisheries and Sport Fish, as per joint-divisional Operational Planning Policy. Documents in this series are planning documents that may contain raw data, preliminary data analyses and results, and describe operational aspects of fisheries projects that may not actually be implemented. All documents in this series are subject to a technical review process and receive varying degrees of regional, divisional, and biometric approval, but do not generally receive editorial review. Results from the implementation of the operational plan described in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author if you have any questions regarding the information provided in this plan. Regional Operational Plans are available on the Internet at: http://www.adfg.alaska.gov/sf/publications/

Charles Brazil, Greg Buck, Suzanne Maxwell, and Craig Schwanke
Alaska Department of Fish and Game, Division of Commercial Fisheries,
333 Raspberry Road, Anchorage, Alaska, 99518, USA

This document should be cited as:
Brazil, C. E., G. B. Buck, S. M. Maxwell, and C. J. Schwanke. 2014. Operational Plan: Stock assessment of Chinook salmon in the Nushagak River drainage, 2014. Alaska Department of Fish and Game, Regional Operational Plan ROP.CF.2A.2014.01, Anchorage.

Signature Page

Project Title:	Stock Assessment of Chinook Salmon in the Nushagak River Drainage
Project leader(s):	Charles Brazil, Greg Buck, Craig Schwanke, and Suzanne Maxwell
Division, Region and Area	Commercial Fisheries, Region 2, Anchorage Sport Fish, Region 2, Anchorage
Project Nomenclature:	Chinook Salmon Research Initiative
Period Covered	2014
Field Dates:	1 June-14 August, 2014
Plan Type:	Category III

Approval

Title	Name	Signature	Date
Project Leader	Charles Brazil		2-14-14
Area Management Biologist	Tim Sands		2-14-14
Biometrician	Xinxian Zin		2-14-14
Research Coordinator	Lowell Fair		2-14-14
Regional Supervisor	Tracy Lingnau		2-14-14

Chinook Salmon Research Initiative Approval

Title	Name	Signature	Date
Fish and Game Coordinator	Ed Jones		2-14-14
Fisheries Scientist	Robert Clark		2-14-14
Fisheries Scientist	Eric Volk		2-14-14

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

PURPOSE

The Nushagak River is 1 of 12 stocks chosen by the Alaska Department of Fish and Game (ADF&G) as an indicator stock and the lack of an inriver abundance estimate has been identified as an information gap. Age-structured production models are widely used to understand stock specific population dynamics and require inriver abundance to produce an estimate of total run. To better understand productivity, the Region II Division of Commercial Fisheries would like to conduct a mark-recapture experiment using passive integrated transponder (PIT) tags and acoustic tags to estimate inriver abundance. Simultaneous and independent estimates of inriver abundance are critical to understanding productivity. This report provides operational guidelines for the stock assessment of Chinook salmon in the Nushagak River drainage.

Key words: Dillingham, Bristol Bay, Nushagak River, Pacific salmon, Chinook salmon, DIDSON, mark and recapture, hydroacoustic tag, hydrophone, spaghetti tag, weir, escapement, stock assessment, fisheries management, operational plan.

BACKGROUND

Chinook salmon are critically important to subsistence, commercial, and sport users across diverse fisheries in Alaska, and recent statewide downturns in productivity and abundance have created social and economic hardships for many communities in rural and urban Alaska. There is a significant need to more precisely characterize productivity and abundance trends of Chinook salmon stocks in the Nushagak River drainage, gather essential information necessary to understand root causes of declines, track population trends, and improve management capabilities into the future (ADF&G Chinook Salmon Research Team. 2013).

The Nushagak River is located in Southwestern Alaska and flows about 390 km from its headwaters into Bristol Bay (Figure 1). The Nushagak drainage has two main tributaries: the Nuyakuk River, draining Tikchik lakes from the west; and the Mulchatna River, which flows into the Nushagak River from the east. The Nushagak River supports one of the largest Chinook salmon runs in Alaska with an average (1966–2012) annual total run of approximately 235,000 and spawning escapement of approximately 157,000 fish.

Nushagak River Chinook salmon are managed under guidelines of the *Nushagak-Mulchatna King Salmon Management Plan*, adopted into regulation in 1992. It was modified in the mid and late 1990s and again in 2012 to account for the conversion of Bendix sonar counts to dual-frequency identification sonar (DIDSON) counts and application to historical escapement numbers (Maxwell et al. 2011). The current sustainable escapement goal is 55,000 to 120,000 fish with an inriver goal of 95,000 (Fair et al. 2012).

ADF&G monitors escapements of salmon at the Portage Creek sonar site located on the lower Nushagak River, approximately 53 km upstream from the terminus of the Nushagak commercial fishing district and 5 km downstream from the village of Portage Creek (Figure 1). At the project site, the Nushagak River is approximately 300 m wide. A DIDSON ensonifies a section of river extending from nearshore to 50 m offshore of the right bank (facing downriver) and 30 m offshore of the left bank, covering less than 27% of the river's width. DIDSON counts are used to develop escapement estimates of sockeye *Oncorhynchus nerka*, Chinook *O. Tshawytcha*, chum *O. keta*, coho *O. kisutch*, and pink *O. gorbuscha* salmon into the Nushagak River (Buck and Brazil 2013). These estimates are used for inseason management of subsistence, commercial and sport fisheries.

The hydroacoustic equipment used to estimate Nushagak salmon escapement from 1979 to 2004 consisted of a single beam 'Bendix' echo-counting system designed by Al Menin for the Bendix

Corporation (King and Tarbox 1989). In 2005 the escapement was estimated with a Bendix on one bank and DIDSON on the other. From 2006 to the present both banks used DIDSON although the inseason estimates for Chinook were standardized in 2010-2012 to make them equivalent to the Bendix count upon which the escapement goal was based (Buck et al. 2012). A new escapement goal based on unadjusted DIDSON numbers was adopted for the 2013 season (Fair et al. 2012) and all historical Bendix numbers were converted to 'DIDSON equivalent' counts (Buck et al. 2012).

The sonar project was originally designed to estimate sockeye salmon which migrate near shore. A radio telemetry study completed by Bristol Bay Science and Research Institute estimated sockeye salmon spawning escapement to within less than 2% of the sonar estimate in 2006 (Daigneault et al. 2007).

While the sonar project was not designed to assess Chinook salmon, it does produce an index of abundance that is used for inseason management of commercial and sport fisheries. The Chinook sonar count has always been considered an index of abundance rather than total abundance because an unknown proportion of Chinook are presumed to migrate upriver beyond the range of the sonar. To gauge the proportion of the Nushagak Chinook escapement that is uncounted and how much annual variation exists in that proportion, the department initiated an acoustic tagging study in 2011. This acoustic tagging project was designed to determine the accuracy of the sonar project's Chinook salmon inriver estimates and potentially recommend sonar siting improvements that might strengthen the sonar estimates (Appendix B1).

OBJECTIVES

The objective for the Nushagak River Chinook Initiative is to produce **two simultaneous and independent estimates** of inriver abundance of Chinook salmon:

1. Use all tagged fish, PIT and acoustic, to estimate the inriver abundance of Chinook salmon (≥400 mm mid-eye to fork [MEF] in length) in the Nushagak River drainage by **Mark-Recapture** such that the inriver abundance estimates are within 20% of the true value 95% of the time.
2. Use acoustic tags to expand the sonar index such that the inriver abundance estimates are within 20% of the true value 95% of the time.

Additional tasks to be accomplished:

a. Estimate the age, sex, and length (ASL) composition of large (≥ 660 mm MEF) and medium (≥ 400-659 mm MEF) Chinook salmon in the Nushagak River to within 5% of the true proportion 95% of the time

b. Count the number of Chinook salmon that pass the weir to within 10% of the true value 90% of the time.

c. Count the number of adult sockeye, chum, coho, and pink salmon that pass through the weir during its operation.

d. Describe the stock specific spawning distribution for select spawning aggregates of Chinook salmon in the Nushagak River drainage.

e. Describe the stock specific migratory timing for select spawning aggregates of Chinook salmon in the Nushagak River drainage.

f. Collect genetic samples to further develop the Chinook salmon baseline.

g. Collect environmental observations (temperature, precipitation, water clarity, etc) on a daily basis at each mark and recapture site.

METHODS

STUDY DESIGN

Simultaneous and independent estimates will be used to assess the inriver abundance of Chinook salmon in the Nushagak River in 2014: (a) PIT (Biomark Inc ®) and acoustic tagging at Scandinavian Slough, located at river mile 25; (b) PIT tagging between Scandinavian Slough, the Nushagak River sonar site, located at river mile 33, and upriver weirs/spawning grounds; Only healthy immigrating salmon caught at Scandinavian Slough and in the non-lethal Nushagak River sonar apportionment test fishery will be tagged and marked as event 1 of two sampling events. Event 2 will use samples from weir sites on the Iowithla (river mile 50.2) and Stuyahok (river mile 129.3) rivers and from spawning ground sampling on the Koktuli, King Salmon, Upper Nushagak, and Mulchatna rivers.

Mark Recapture Estimate

Event 1–Tagging

Scandinavian Slough

Personnel from ADF&G will capture Chinook salmon with 6” and 8” drift gillnets and hook-line gear in the lower Nushagak River near Scandinavian Slough (Figure 2). Three separate crews will be used during the tagging event. Two crews of two ADF&G personnel will drift gill nets and another crew of two ADF&G personnel will use hook–line gear.

Every Chinook salmon captured will be sampled for age, sex, and length (ASL). All captured fish will be released. Healthy fish released in good condition will be marked either with a primary PIT tag or hydroacoustic tag and secondary spaghetti tag along with two additional secondary marks as follows.

Gillnet Crew I:
Primary Mark- PIT tag.
Secondary Mark- A Spaghetti tag on the preferred side inserted just posterior to the dorsal fin and a left axillary appendage (LAA) fin clip.

Gillnet Crew II:
Primary Mark- PIT and Acoustic tag
Secondary Mark- A Spaghetti tag on the preferred side inserted just posterior to the dorsal fin and a left axillary appendage (LAA) fin clip.

Hook and Line Crew:
Primary Mark- PIT tag.
Secondary Mark- A Spaghetti tag on the preferred side inserted just posterior to the dorsal fin and a left axillary appendage (LAA) fin clip.

These secondary marks will ensure that tagged fish are recognized as such when encountered during the non-lethal sonar apportionment test fishery portion of event 1 and during sampling event 2 and to detect tag loss.

Inriver non-Lethal Sonar Species Apportionment Test Fishery

Catches from the inriver non-lethal sonar apportionment test drift fishery approximately 8 river miles upstream of Scandinavian Slough will be used as part of event 1.

The inriver non-lethal sonar apportionment test drift fishery catch will have a sampling target of 100% for length, primary tags, secondary marks, and every fish will be sampled for ASL. All captured fish will be released. Healthy fish released in good condition will be marked as follows.

Primary Mark- PIT tag.
Secondary Mark- A Spaghetti tag on the preferred side inserted just posterior to the dorsal fin and a left axillary appendage (LAA) fin clip.

These secondary marks will ensure that tagged fish are recognized as such when encountered during the non-lethal sonar apportionment test fishery portion of event 1 and during sampling event 2 and to detect tag loss.

Capture and Marking

All captured Chinook salmon deemed healthy enough for tagging will receive a PIT tag, with a subset receiving an acoustic tag as well. All tagged fish will receive two secondary marks; 1) a spaghetti tag on the preferred side inserted just posterior to the dorsal fin and 2) a left axillary appendage (LAA) fin clip (Table 1). Four crews will capture, mark and release fish at two locations: Scandinavian Slough and the inriver non-lethal test fishery conducted as part of the existing sonar operations (Buck and Brazil 2013). Three two person crews will mark fish at Scandinavian Slough (Objectives 1 and 2) using gillnets, 20.6 cm (8.125 in), 15.2 cm (6.0 in), and hook and line gear. A single 2 person crew will mark Chinook salmon caught during the non-lethal apportionment sonar apportionment test fishery (Objective 1) using a suite of gillnets, 20.6 cm (8.125 in), 15.2 cm (6.0 in), 13.0 cm (5.125 in) (Buck and Brazil 2013).

PIT Tagging

Passive integrated transponder (PIT) tags will be inserted into the cheek of all healthy Chinook salmon captured using a MK 25 implant gun during the project. HPT12 PIT tags will be used in this study because they are small (12.5mm), quick to apply, not visible externally (to avoid enhancing predation), internal (no Hydrodynamic drag), uniquely numbered, can be identified automatically, and can be scanned without handling fish. The tags will be interrogated by a 134.2 kHz signal from a Biomark 601 handheld reader and to verify that the tag is inserted into the cheek. Tag loss is expected to be negligible (Willette et. al 2012).

Acoustic Tagging

Personnel from ADF&G will capture Chinook salmon with 6” and 8” drift gillnets and hook-line gear in the lower Nushagak River near Scandinavian Slough, tagging only healthy fish with esophageal Lotek MMTP-16-25 (76.8kHz, 2 second ping rate) acoustic tags. In-depth details are found in the Nushagak Acoustic Tag Study Field Operational Plan (Appendix B1).

Event 2–Weir (Iowithla and Stuyahok), and Spawning Ground Sampling

Primary tag recovery locations will be the Iowithla (Figure 3) and Stuyahok river’s (Figure 4) resistance board weir sites designed similar to those described in Stewart (2002, 2003) and Tobin (1994). Spaces between adjacent pickets on the weir and live trap will be approximately 1.5 in; and should prevent all but the smallest 0-ocean-age (jack) Chinook salmon from passing between pickets. Both floating weir sites will have a fish trap and passage chute, each with two antennas to detect PIT tags. All Chinook salmon will be inspected for marks. Weirs will operate continuously throughout the operational period. All tagged Chinook salmon successfully recovered will be released after biological data are collected. Non-tagged Chinook salmon will also be released after biological data are collected.

Secondary tag recovery sampling will potentially occur on several spawning locations, Koktuli, King Salmon, Upper Nushagak, and Mulchatna rivers. Spawning ground sampling will concentrate on moribund fish as opposed to carcasses because marks will be more easily recognizable on live fish. Using a combination of gear types during spawning grounds sampling produces the least biased estimates (non-size-selective) of abundance, age, sex, and size composition (McPherson et al. 1997).

All fish sampled on the spawning grounds will be inspected for marks. Presence or absence of primary and secondary marks will be noted. All fish will be sampled for ASL data. All live sampled fish will be marked lower left operculum punch (LLOP) before release to identify them as having been previously sampled. All sampled carcasses will be marked by multiple slashes on the left side of the carcass.

For the estimate of abundance from this mark-recapture experiment to be unbiased, certain assumptions must be met (Seber 1982). These assumptions, expressed in this study, along with their respective design considerations and test procedures can be found in Appendix A1 and A2.

Sonar Expansion Estimate

The existing salmon escapement enumeration project on the Nushagak River uses a Dual Frequency Identification Sonar (DIDSON) on each bank of the river at a site near Portage Creek to count upriver migrating salmon. This raw sonar count is then apportioned on a daily basis into species counts based on the proportional catch-per-unit-effort (CPUE) of each species in a drift gillnet test fishery operated just downriver from the sonar emplacements (Buck and Brazil, 2013). The DIDSON covers a little less than a quarter of the total river channel closest to the banks. While most salmon species travel almost exclusively within the coverage of the DIDSON, Chinook salmon use the entire river channel, therefore our Chinook count is an index of the total Chinook escapement. We assume that the Portage Creek sonar project counts a consistent portion of the Chinook escapement. In 2011 a study using acoustic tags and a hydrophone array co-located with the DIDSONs was begun to test that assumption (Appendix B). This study had funding through 2013. One of the stated objectives of this study was to '*determine the proportion of migrating Chinook salmon outside the range of the DIDSON, and use that proportion to expand the DIDSON-based count into a total inriver estimate*' (Appendix B). Continuing this study will give us a meaningful independent inriver abundance estimate to compare with the mark recapture estimate.

DATA COLLECTION

Sample Size

Our minimum sampling goal for event 1 is to mark a total of **600** **(=n_1 CYI)** Chinook salmon (≥400 mm mid-eye to fork [MEF] in length, Objective 1), of which 200 will be acoustic tags used for both Objective 1 and 2. It is likely that much more than 600 Chinook salmon will be marked. We will need to inspect at the weir sites and sample on the spawning grounds such that the event 2 sample size is **30,000 (=n_2 total)** in 2014 and the estimate is within ±20% of the true value 95% of the time according to methods in Robson and Regier (1964).

These projections of expected precision for estimates of spawning escapement of large (≥ 660 mm MEF) and medium (≥ 400-659 mm MEF) Chinook salmon are based on the assumption that a simple Petersen-type model will be appropriate for estimating abundance. If some portions of the second event data, such as from the weirs and spawning grounds must be censored to eliminate potential bias, the precision criteria stated in Objectives 1 and 2 will not be met. Also, if the methods of Darroch (1961) must be used to estimate abundance due to temporal and/or geographic capture heterogeneity during both first and second sampling events, it is unlikely that the precision criteria will be met.

Age, Sex, and Length Composition

Samples taken for the mark-recapture experiment should be sufficient to meet objective criteria for estimating relative age composition. Information on age composition obtained at the Scandinavian Slough Tagging site, Nushagak Sonar site, weirs and on the spawning grounds will be tabulated separately. History has shown that the pooled tributary sample (within medium and large size groups) produces unbiased estimates of age and length composition for the spawning population (McPherson et al. 1997).

Based on procedures in Thompson (1987) for a 5-age-class population, 509 samples are needed to meet objective criteria if all scales are readable. Because of the high rate of scale regeneration among Chinook salmon, 3 scales will be collected from Chinook salmon (Appendix A3). Scale numbers 2 and 3 will be collected immediately to the left and right of the preferred scales on row number 2 above the lateral line. Scales will be collected from the left side of the fish approximately 2 rows above the lateral line in the area crossed by a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1963). Scales will be mounted on corresponding gum cards, which will be covered with wax paper after drying and placed in a press to keep from curling. Approximately 20% of adult scale samples from Chinook salmon have in the past proven unreadable, therefore 636 (509/0.80) fish need to be sampled to meet criteria for each age group of fish. More than this number of scales will be collected at each venue. These sample sizes will also meet sex composition requirements, as only 384 samples (assuming no data loss) are necessary to achieve the precision criteria for estimating sex composition (Cochran 1977). Sex is determined from morphological characteristics, such as kype development, or protruding ovipositor (Groot and Margolis 1991). Fish will be measured to the **nearest millimeter** from the mid-eye to fork-of-tail (Appendix A4). Sex, length and species will be recorded on Rite-in-the-Rain forms.

Capture and Marking

Scandinavian Slough

Personnel from ADF&G will capture Chinook salmon with 6” and 8” drift gillnets and hook-line gear in the lower Nushagak River near Scandinavian Slough. All healthy fish will be PIT tagged (Objective 1), additionally a subset of fish will be tagged with acoustic tags (Objective 2). PIT tags applied to Chinook salmon during the project will be interrogated by a 134.2 kHz signal from a Biomark 601 handheld reader. The Biomark 601 handheld reader will be interfaced with a computer and the information downloaded into the tag manager software daily.

Acoustic tags will be applied to only healthy fish with esophageal Lotek MMTP-16-25 (76.8kHz, 2 second ping rate) active acoustic tags. As tagged Chinook salmon that migrate past the hydrophone array will have their presence recorded. In-depth details are found in the Nushagak Acoustic Tag Study Field Operational Plan (Appendix B1). Date, time, location, gear type, ASL, and genetics will be collected concurrently with the tagging progress for each crew.

Inriver non-Lethal Apportionment Test Fishery

Immigrating Chinook salmon caught in drift gillnets, 20.6 cm (8.125 in), 15.2 cm (6.0 in), 13.0 cm (5.125 in), upriver of Scandinavian Slough at the Nushagak Sonar site will be sampled for tags and secondary marks. All untagged healthy fish will be tagged with a uniquely numbered PIT tag and two secondary marks, a spaghetti tag and a clipped left axillary appendage (LAA). These fish will then be included as part of the event 1 release group in the 2-event mark-recapture study. Those fish possessing a primary PIT or acoustic tag or secondary marks will have the PIT and spaghetti tag number recorded and will be released immediately. Fish possessing only secondary marks and missing the primary tag or secondary spaghetti tag will be noted as such and retagged with a new PIT and or spaghetti tag and released immediately. All fish having not been previously tagged with a primary PIT or acoustic tag will be marked and sampled for age, sex, and length (MEF) information recorded following the protocols in the Assessment of Pacific Salmon Escapement into the Nushagak River Regional Operation Plan (Buck and Brazil 2013).

Weirs (Iowithla and Stuyahok)

Escapement

At each weir site, the following information will be collected daily:

1. Number of marked and unmarked Chinook salmon that passed through the live trap and those detected by PIT tag antennas, including tag number or secondary marks;
2. Number of salmon by species counted through the live trap;
3. Number of salmon by species sampled for ASL;
4. Number of other fish, by species, that passed through the live trap;
5. Water stage and water temperature; and
6. Comments regarding ability to accurately count salmon through the live trap.

This information will be recorded on the daily weir report form (Appendix A5). PIT tag information will be downloaded daily from the PIT Tag Detection System, IS1001 data logger, into the tag manager software excel file. Daily and cumulative counts of salmon including fish sampled for ASL will be recorded in a Rite-In-the-Rain notebook that will be turned into the crew leader at the end of the season.

The crew will clean and inspect the weir for gaps that would allow salmon to pass undetected daily. The crew will monitor the weir during daylight hours and pass fish in a timely fashion to minimize impeding migration upstream.

ASL Sampling

All Chinook salmon passing through the trap will be inspected for primary and secondary tag marks; however fish having lost a primary tag may not be identified solely from their secondary mark. All fish in the trap will be sampled to prevent selection bias. The number of fish sampled daily for ASL will vary according to fish passage in order to maintain the desired sampling ration for each river. The sampling ratio for the Iowithla River will be 1:15 and the Stuyahok River will be 1:30 in order to achieve the minimum 636 fish sampling objective and meet the criteria for each age group of fish. More than this number of scales will be collected at each weir site.

Spawning Ground Sampling

All Chinook encountered on the spawning grounds will be sampled. Sampling will concentrate on moribund fish as opposed to carcasses because marks have proven to be more easily recognized on living fish. A combination of gear types will be used to capture live salmon including hook–line gear and entanglement nets. Note that the first time a Chinook salmon is examined on the spawning grounds; a ¼-inch hole will be punched on the *lower* left operculum (LLOP). Each fish will be inspected for a primary mark (individually numbered tag) and secondary marks, and a mark indicating that the fish had been previously inspected (adipose fin clip). It is crucial that during the spawning grounds sampling, we obtain an accurate count of the total number of fish inspected by size and age category and, of those, accurately detect any fish that were marked at Scandinavian Slough or the non-lethal apportionment test fishery without double sampling.

The following steps will be used for sampling each fish encountered. Look for the LLOP or slashes, and if either mark is present, go on to the next fish. For fish that do not have an LLOP, look for (1) spaghetti tag, (2**)** a LAA, or (3) an adipose fin clip. Any of the four indicate this fish was marked at Scandinavian Slough or in the non-lethal sonar apportionment test fishery, and this fish is a valid recovery. If present, record the number written on the spaghetti tag and whether or not either secondary mark is present apply a LLOP and/or slashes and move on to the next specimen. All data, including the date, fish number (1-10), sex, length (MEF), spaghetti tag number (if present) and the presence or absence of an adipose fin will be recorded for each fish that has not been previously sampled will be recorded on the **SPAWNING GROUNDS SAMPLE FORM** (Appendix A6). Note that it is imperative to look for the presence or absence of the LAA or adipose fin clip, in the event that the spaghetti tag has fallen off.

Genetic Sampling

Event I

The goal at each tagging site is to collect individual paired samples from tagged Chinook salmon. Approximately 2–3cm of the left axillary process will be clipped and placed into an individual vial of ethanol to preserve the tissue. Vial numbers will be assigned so individual fish will have paired genetic, ASL information. At the end of the field season the tissue containers will be returned to the Gene Conservation Laboratory in Anchorage. Genetic sampling instructions are shown in Appendix A7.

Event II

The goal at each weir site and from spawning ground sampling is to collect a minimum of 100 genetic samples from untagged Chinook salmon. A bulk container will be provided in advance of the field season by the Gene Conservation Laboratory. Approximately 2–3cm of the left axillary process will be clipped and placed into a bulk or individual container of ethanol to preserve the tissue. At the end of the field season the tissue containers will be returned to the Gene Conservation Laboratory. Genetic sampling instructions are shown in Appendix A7.

DATA ANALYSIS

Adult Abundance

A two-sample mark-recapture model will be used to estimate the number of Chinook salmon in the Nushagak River Drainage. The appropriate abundance estimator will depend on the results of the aforementioned tests in Appendices A1-A3. If stratification by size is not needed and assuming no need for stratification by time/area, a modified form of Chapman's version of Petersen's abundance estimator for closed populations (see Seber 1982) will be used:

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \tag{1}$$

where $\hat{N}$ = estimated number of large Chinook salmon, $\hat{n}_1$ = estimated number of large marked Chinook salmon moving upstream of Scandinavian Slough and the non-lethal sonar apportionment test fishery, n_2 = number of large adults inspected for marks at the weirs or on the spawning grounds, and m_2 = number of marked large adults recaptured at the weirs or on the spawning grounds. Note that the same estimator will be used for medium-sized fish as well. Further description of analyses will implicitly represent calculations and tests for both large and for medium-sized fish.

The number of large marked fish that will be available for recapture will be estimated:

$$\hat{n}_1 = k - \left(r_a + r_b + r_c\right) \tag{2}$$

where k = number marked at Scandinavian Slough and the non-lethal sonar apportionment test fishery; r_a = number of marked fish recovered from the Nushagak District commercial fishery and r_b = number of marked fish recovered in the sport fishery and r_c = number of marked fish recovered in the subsistence fishery. The same estimator will be used for medium-sized fish as well.

All diagnostic tests for equal probability of capture (Appendix A2, A3) will be performed on the mark-recapture data:

a. The event 1 sample will consist of all fish marked and released at Scandinavian Slough or the inriver non-lethal sonar apportionment test fishery. The event 2 sample will consist of fish inspected for marks at the weir sites or on the spawning grounds.

If temporal/geographic stratification is not required but stratification by size or sex is required (see Appendix 2), estimates for each stratum will be generated using equations (1) and (2) and these estimates summed to estimate total abundance and variance.

An estimate of the variance for $\hat{N}$ will be obtained through bootstrapping (Efron and Tibshirani 1993). A large number (B) of bootstrap samples will be drawn.

The approximate variance will be calculated as:

$$\text{var}(\hat{N}) = \frac{\sum_{b=1}^{B} (\hat{N}_b^* - \hat{\bar{N}}^*)^2}{B-1} \tag{3}$$

where $\hat{\bar{N}}^{*}$ is the average of the $\hat{N}_b^{*}$.

PIT Tagging

Data processing will be done post-season. PIT tags applied to Chinook salmon during the project interrogated by a 134.2 kHz signal from a Biomark 601 handheld reader will be interfaced with a computer and the information downloaded daily into the tag manager software excel file. PIT tag information from the weir sites will also be downloaded daily from the PIT Tag Detection System, IS1001 data logger, into the tag manager software excel file. Scales collected during ASL sampling will be processed post season and used to produce an estimate of Chinook age composition.

Accoustic Tagging

An array of 7 Lotek WHS 3000 series hydrophones will be deployed on tripod mounts in the area of the DIDSONs to form an array that will cover approximately 300m of river and encompass both DIDSON coverage areas. Three hydrophones will be used on the south bank and 4 on the north bank. Hydrophones will be synchronized with each other prior to deployment. One hydrophone in the array will be examined weekly as a check against excessive tag mortality and hydrophone power consumption. Hydrophones will not be moved before the end of the study unless disturbed or if falling river level dictates a redeployment of the array or if power level falls below 6 v. Post-season data processing will use the latest version of ALPS to obtain position estimates for detected tags. Text files exported from ALPS will be concatenated by tag number and imported into TIBCO Spotfire S+ v.8.1 where the fish tracks will be filtered.

Each acoustic tag will be examined individually and a probability of a fishes being available to the sonar count *Pr(count)* will be estimated. If a fish clearly swims through the area of DIDSON coverage and never returned to the sonar site *Pr(count)*=1 and if a fish clearly swims upriver outside of the DIDSON coverage zones *Pr(count)*=0. Fish that are somewhat ambiguous due to imprecision of the tracks, multiple trips through the hydrophone array or other scenarios will be assessed a *Pr(count)* between 0 and 1 (Maxwell, pers. comm.). The average *Pr(count)* for all tags will be used to expand the sonar count into an estimate of inriver abundance. We will also look at the probabilities to see if it changes through time and by fish size.

Fish Weirs

Daily escapement counts will be recorded for Iowithla and Stuyahok River weirs. Weir counts will be assumed to be total counts of escapement if weirs remain fish tight and are in place for the complete duration of the run. Scales collected during ASL sampling will be processed post season and used to produce an estimate of Chinook age composition in the Iowithla and Stuyahok Rivers.

Age/Sex Composition

The fraction p_{ij} of spawning fish in age (or sex or length) group *j* in stratum *i* (large or medium, or small fish) will be estimated as:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \tag{4}$$

where n_i = the number of large (or medium-sized or small) fish sampled on the spawning grounds, and n_{ij} = the number from this sample that belong to age (or sex or length) group j; note that $\sum_j p_{ij} = 1$. Estimated variance for $\hat{p}_{ij}$ is:

$$\hat{\text{var}}(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1} \tag{5}$$

The estimated abundance of group j in the population ($\hat{N}_j$) is:

$$\hat{N}_j = \sum_i \hat{p}_{ij}\hat{N}_i \tag{6}$$

where $\hat{N}_i$ = the estimated abundance in stratum i of the mark-recapture experiment. From Goodman (1960), $\text{var}(\hat{N}_j)$ is a sum of the products of the estimated variances for $\hat{N}_i$ and for $\hat{p}_{ij}$:

$$\text{var}(\hat{N}_j) = \sum_i [\text{var}(\hat{p}_{ij})\hat{N}_i^2 + \text{var}(\hat{N}_i)\hat{p}_{ij}^2 - \text{var}(\hat{N}_i)\,\text{var}(\hat{p}_{ij})] \tag{7}$$

The estimated fraction of the population that belongs to group j ($\hat{p}_j$) is:

$$\hat{p}_j = \frac{n_{.j}}{n} \tag{8}$$

Where $\hat{N} = \sum_i \hat{N}_i$

The variance of the estimated fraction can be approximated with the delta method (see Seber 1982):

$$\hat{\text{var}}(\hat{p}_{.j}) = \frac{\hat{p}_{.j}(1-\hat{p}_{.j})}{n-1} \tag{9}$$

The diagnostic tests described in Appendix A2 will be used to identify any size and/or sex selectivity within large and medium Chinook stratum. If further stratification is required to eliminate bias due to size or sex selective sampling, equations 4-9 will be applied to calculate unbiased estimates.

Mean Length

Chinook mean length at age class k will be estimated by:

$$\bar{l}_k = \frac{1}{n_k}\sum_{i=1}^{n_k} l_i \tag{8}$$

where

l_i = the length of fish i in a sample n_k and

n_k = the number of Chinook of age class k.

The variance of the mean length-at-age class k will be estimated by:

$$\mathrm{var}(\bar{l}_k) = \frac{1}{n_k} \frac{\sum_{i=1}^{n_k} (l_i - \bar{l}_k)^2}{n_k - 1} \qquad (9)$$

SCHEDULE AND DELIVERABLES

Dates of office and field activities are summarized in the table below. Budget for the stock assessment project can be found in Table 2. The general field camp policy is in Appendix C1. Project data will be analyzed and reported in an ADF&G peer reviewed Fisheries Data Series Report in spring of the following year. An annual summary memo for the Stock Assessment of Chinook Salmon in the Nushagak River Drainage will also be prepared for release to staff.

Schedule	Deliverables
January 1 – March 31	Budget, Hiring, and Logistics
April 1 – May 31	Logistics and Field Preparation
June 1 – August 31	Field Season
September 1 – September 30	Data Analysis
October 1 – November 30	Season Summary / Report Writing

RESPONSIBILITIES

Charles Brazil, Bristol Bay Area Research Biologist, ADF&G. Duties: Oversees all aspects of the Project.

Greg Buck, Assistant Area Research Biologist-Bristol Bay, ADF&G. Duties: Assistant project leader. Assists with budget, hiring, and logistics. Co-author of operational plan, progress reports, and final technical report.

Craig Schwanke, Assistant Area Management Biologist-Bristol Bay, ADF&G. Duties: Assistant project leader. Assists with budget, hiring, and logistics. Co-author of operational plan, progress reports, and final technical report.

Suzanne Maxwell, Region II Sonar Coordinator, ADF&G. Duties: Oversee installation and setup of the SR-DIDSON and LR- DIDSON. Provide technical support and advice on the collection of sonar data. Assists with all aspects of hydroacoustic tagging operations and provide review of reports.

April Faulkner, Assistant Region II Sonar Coordinator, ADF&G. Duties: Assist with setup of hydrophone arrays, DIDSON's at the Nushagak Sonar Camp, and preseason in-situ testing of both systems

Xinxian Zhang, Biometrician, ADF&G. Duties: Provide statistical supervision and assist in project design. Provide statistical review of data analysis. Provide biometric review of reports.

Lowell Fair, Region II Research Coordinator, ADF&G. Duties: Provide review and approve final project design, budget, and reports.

Fishery Biologist I, Tagging and Weir Crew Leader, ADF&G. Duties: Supervise a crew of 4-6 ADF&G Fish and Wildlife Technicians. Assist project biologist in planning and execution of field logistics. Assist project leader in overseeing daily tagging and weir operations. Prepare work schedule, assist with data collection, data analysis, and report writing.

Fishery Technicians, ADF&G. Duties: Conduct daily hydrophone tagging operations, weir operations, and data collection. Assist in mobilization and demobilization of field camp and maintenance.

Konrad Mittlestadt, Nushagak Sonar Crew Leader, ADF&G. Duties: Supervise a crew of 5 ADF&G Fish and Wildlife Technicians, and monitors the work of one or 2 technicians from various other agencies. Assist project biologist in planning and execution of field logistics. Assist project leader in overseeing daily sonar and test fish operations. Prepare work schedule and assist with data collection.

Cathy Tilly, Fish and Wildlife Technician, ADF&G. Duties: Ages scales from the Nushagak River drainage and completes mark-sense forms.

Fred West, Assistant Area Research Biologist, ADF&G. Duties: Edits and combines age composition with escapement and catch data and writes season summary.

Judy Berger, Fisheries Biologist, Genetics, ADF&G. Duties: Responsible for collection coordination, tissue tracking, and archiving.

Nick Decovich, Fisheries Biologist, Genetics, ADF&G. Duties: Provide program supervision and review of operational plan and reports.

REFERENCE CITED

ADF&G Chinook Salmon Research Team. 2013. Chinook salmon stock assessment and research plan, 2013. Alaska Department of Fish and Game, Special Publication No. 13-01, Anchorage.

Bailey, N. J. T. 1951. On estimating the size of mobile populations from capture-recapture data. Biometrika 38: 293-306.

Bailey, N. J. T. 1952. Improvements in the interpretation of recapture data. Journal of Animal ecology 21: 120-127.

Bernard, D. R., J. J. Hasbrouck, and S. J. Fleischman. 1999. Handling-induced delay and downstream movement of adult chinook salmon in rivers. *Fisheries Research* 44:37-46. Sal

Buck, G. B., and C. E. Brazil. 2013. Operational Plan: Assessment of Pacific mon Escapement into the Nushagak River, 2013. Alaska Department of Fish and Game, Regional Operational Plan ROP.CF.R2.13.04, Anchorage.

Cochran, W. G. 1977. Sampling techniques. Third ed. John Wiley and Sons, New York, N.Y.

Daigneault, M. J., J. J. Smith, and M.R. Link. 2007. Radiotelemetry monitoring of adult Chinook and sockeye salmon in the Nushagak River, Alaska, 2006. Unpublished report prepared by the Bristol Bay Science and Research Institute, Dillingham, AK, 99576. 66 p.

Darroch, J. N. 1961. Two-sample capture-recapture census when tagging and sampling are stratified. Biometrika 48: 241-60.

Efron, B., and R. J. Tishirani. 1993. An introduction to the bootstrap. Chapman Hall, New York. 436 p.

Fair, L. F., C. E. Brazil, X. Zhang, R. A. Clark, and J. W. Erickson. 2012. Review of salmon escapement goals in Bristol Bay, Alaska, 2012. Alaska Department of Fish and Game, Fishery Manuscript Series No. 12-04, Anchorage.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association. 55: 708–713.

INPFC (International North Pacific Fisheries Commission). 1963. Annual report 1961, Vancouver, British Columbia.

King, B. E., and K. E. Tarbox. 1989. Upper Cook Inlet salmon escapement studies, 1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fisheries Report 89-19, Juneau.

Maxwell, S. L., and G. B. Buck. Nushagak Acoustic Tag Study, 2012. Alaska Department of Fish and Game, Field Operation Plan, Anchorage, Unplished.

Maxwell, S. L., A. V. Faulkner, L. Fair, and X. Zhang. 2011. A comparison of estimates from 2 hydroacoustic systems used to assess sockeye salmon escapement in 5 Alaska Rivers. Alaska Department of Fish and Game, Fishery Manuscript Series No. 11-02, Anchorage.

McPherson, S. A., D. R. Bernard, S. K. Kelley, P. A. Milligan and P. Timpany. 1997. Spawning abundance of Chinook salmon in the Taku River in 1996. Alaska Department of Fish and Game, Division of Sport Fisheries, Fisheries Data Series Report 97-14, Anchorage.

Robson ,D. S., and H. A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Transactions of the American Fisheries Society 93:215-226.

Seber, G. A. F. 1982. On the estimation of animal abundance and related parameters. 2nd. ed. Charles Griffin and Sons, Ltd., London. Page 64-69 and 654.

Stewart, R. 2002. Resistance board weir panel construction manual, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A02-21, Anchorage. http://www.sf.adfg.state.ak.us/FedAidpdfs/RIR.3A.2002.21.pdf

Stewart, R. 2003. Techniques for installing a resistance board weir, 2003. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A03-26, Anchorage.

REFERENCES CITED (Continued)

Tobin, J. H. 1994. Construction and performance of a portable resistance board weir for counting migration adult salmon in rivers. U. S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 22, Kenai, Alaska.

Thompson, S. K. 1987. Sample size for estimating multinomial proportions. American Statistician. 41-42-46.

Willette, T. M., T. McKinley, R. D. DeCino, and X. Zhang. 2012. Inriver abundance and spawner distribution of Kenai River sockeye salmon, Oncorhynchus nerka, 2006-2008: a comparison of sonar and mark–recapture estimates. Alaska Department of Fish and Game, Fishery Data Series No. 12-57, Anchorage.

TABLES AND FIGURES

Table 1.–Tag deployment summary.

Objective	Location	Gear	Primary Tag	Secondary Tag(s)	ASL Sample Taken?	Genetic Sample Taken?	Anticipated Sample Size In proportion to run strength and timing
1	Scandanavian Slough	6 & 8 1/8 in net	PIT	Spaghetti tag, left axillary appendage clip (LAA).	Yes	Yes	600
1 & 2	Scandanavian Slough	6 & 8 1/8 in net	PIT and Acoustic	Spaghetti tag, left axillary appendage clip (LAA).	Yes	Yes	200
1	Scandanavian Slough	Hook and line	PIT	Spaghetti tag, left axillary appendage clip (LAA).	Yes	Yes	400
1	Inriver apportionment test drift fishery	5 1/8, 6 & 8 1/8 in net	PIT	Spaghetti tag, left axillary appendage clip (LAA).	Yes	Yes	400

Note: The left axillary appendage clip is the materal taken for genetic sampling and the process leaves for what is all intents and purposes a secondary mark.

Table 2.–Budget for the stock assessment of Chinook salmon in the Nushagak River drainage, 2014.

FY 14 (2014)						
Line Item	100	200	300	400	500	Total
Allocation	$138,603.00	$6,000.00	$45,936.00	$294,948.00	$184,200.00	$669,687.00
Obligated	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Balance	$138,603.00	$6,000.00	$45,936.00	$294,948.00	$184,200.00	$669,687.00
Projected Expenses	$138,603.00	$6,000.00	$45,936.00	$294,948.00	$184,200.00	$669,687.00
Projected Balance	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
FY 15 (2014)						
Line Item	100	200	300	400	500	Total
Allocation	$253,500.00	$2,400.00	$46,850.00	$159,525.00	$0.00	$462,275.00
Obligated	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Balance	$253,500.00	$2,400.00	$46,850.00	$159,525.00	$0.00	$462,275.00
Projected Expenses	$114,900.00	$0.00	$38,750.00	$6,750.00	$0.00	$160,400.00
Projected Balance	$138,600.00	$2,400.00	$8,100.00	$152,775.00	$0.00	$301,875.00

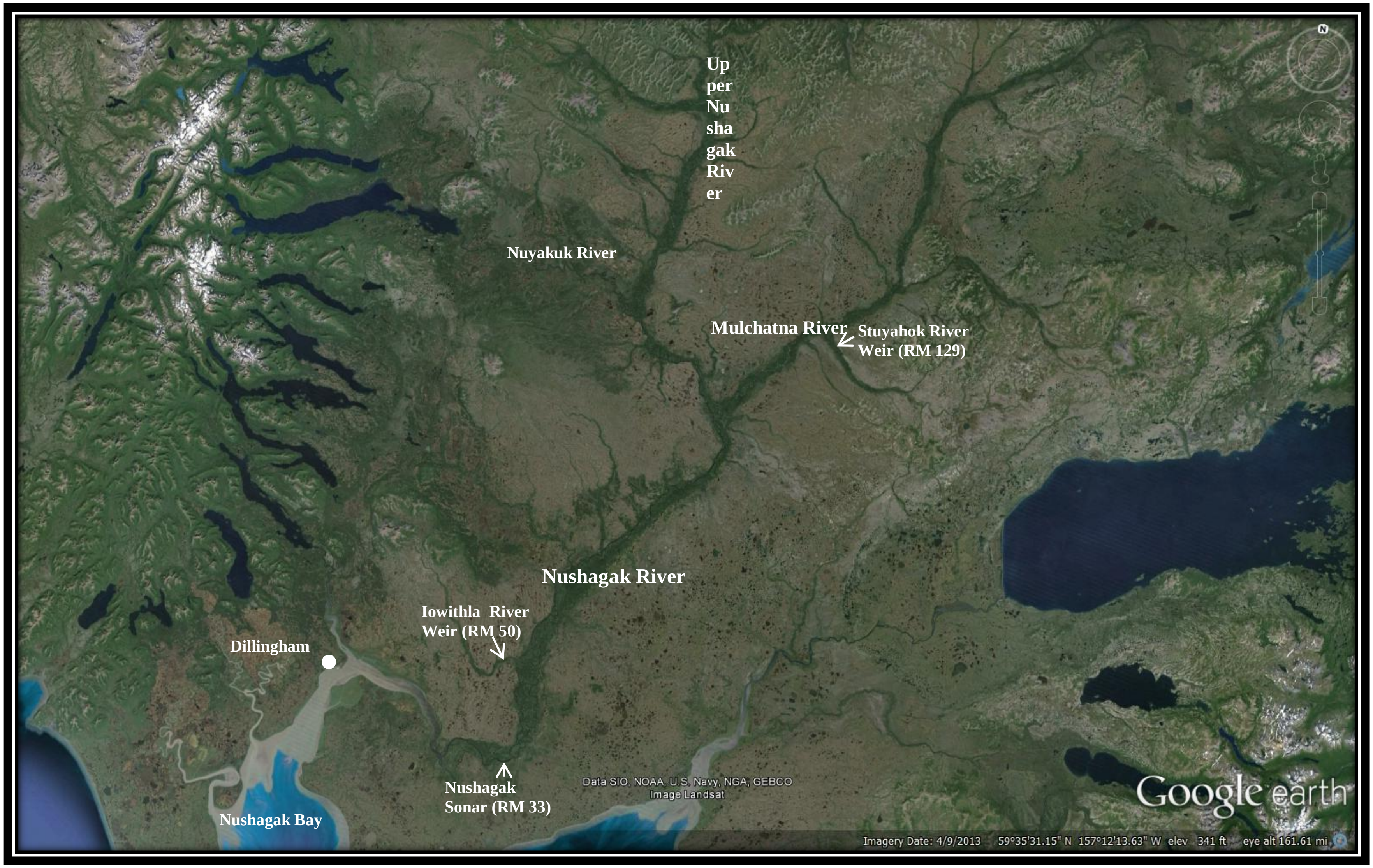


Figure 1.–Escapement enumeration projects, Nushagak Drainage, Bristol Bay, Alaska.

Figure 2.–Tagging sites used for acoustic and mark recapture tagging in relation to the Portage Creek sonar site.

Figure 3.–Potential weir site on Iowithla River.

Figure 4.–Potential weir site on Stuyahok River.

APPENDIX A: SAMPLING

Assumption I: Population is closed to birth, death, immigration, and emigration.

Considering the life history of Chinook salmon, there should be no recruitment between sampling events. First event sampling (marking) will begin prior to any significant passage of fish past the tagging sites and will continue through the run until passage has dropped to near zero. The population of Chinook salmon passing by Scandinavian Slough is closed to recruitment because of the fidelity of salmon to their natal stream.

Assumption II: Marking and handling will not affect the catchability of Chinook salmon in the second event.

There is no explicit test for this assumption because the behavior of unhandled fish cannot be observed. There may be some gear-induced behavior that, with no adjustment, may bias estimated abundance. In response to being handled, marked Chinook salmon have a tendency to delay their upstream migration upon release, even temporarily heading downstream into marine waters before resuming their upstream migration (Bernard et al. 1999).

The adjustment for this phenomenon is to censor any marked fish caught in marine fisheries. To that end, the Commercial Fisheries Division (CFD) will sample harvest in the commercial gillnet fishery from the Nushagak District near Dillingham to recover fish marked. The primary purpose of this independent sampling program is to recover tagged fish. While looking for tagged fish, any secondary marks from our mark-recapture experiment will be noted. The number of fish recaptured in the commercial fishery will be expanded according to the fraction of harvests inspected for marks and the result subtracted from the number marked (see Data Analysis section). There should be no trap-induced behavior because different sampling gears are used in different sampling events. However, we will attempt to meet this assumption by minimizing holding and handling time of all captured fish. Any obviously stressed or injured fish will not be tagged.

Assumption III: Tagged fish will not lose their marks between sampling events and all marks are recognizable and detected.

The use of multiple marks will ensure that marks are not lost and that all marked fish are recognizable during second event sampling. Fish may shed tags during transit but will be identified as marked fish by a clipped left axillary appendage (LAA). Experience has shown a low rate of primary tag loss (PIT and spaghetti) and some fading of the opercular punch can occur. However, there has been no recorded instance on any recoveries of an LAA being unrecognizable as a mark. Marking fish with an operculum punch (LLOP) and slashing carcasses will prevent double sampling in the second event. There may be some failure to recognize marked fish caught in the subsistence or sport fishery. Rate of voluntary return of tags may not be 100%, and some fishermen might not recognize secondary marks if the primary mark (tag) is lost as the fish struggles in the net and will cause bias. Marked fish harvested in the commercial, sport, or subsistence fishery will be subtracted from the total number of marked fish and will be the number of marked fish available for recapture.

Assumption IV: One of three conditions will be met.

1. All Chinook salmon will have the same probability of being caught in the first event;
2. All Chinook salmon will have the same probability of being captured in the second event; or
3. Marked fish will mix completely with unmarked fish between samples.

In our experiment, it is unlikely that marked and unmarked fish will mix completely. Also, all Chinook salmon will not have an equal probability of being inspected for marks during event 2 sampling, as not every spawning location will be sampled. Under these circumstances it is necessary that event 1 sampling be conducted to ensure that condition (1) will be satisfied. While probability of capture during event 1 may vary from day to day due to short-term changes in sampling conditions, attempting to maintain similar effort over the entire run will be necessary to ensure that the final spawning destination of different stocks of Chinook salmon within the Nushagak River system is independent of the probability of capture during event 1.

Equal probability of capture will be evaluated by time, area, size, and sex. The experimental design already considers gear selectivity and procedures to analyze sex and length data for statistical bias due to gear selectivity. If different probabilities are indicated, abundance estimates will be stratified by category.

To further evaluate the three conditions of this assumption, contingency table analyses recommended by Seber (1982) will be used to detect significant temporal or geographic violations of assumptions of equal probability of capture. This test may not be necessary because the source of unequal catchability in the marked event is independent of the recapture event.

Further, the tendency for some Chinook salmon to delay upstream migration immediately after release may result in a higher probability of capture for marked versus unmarked fish a short distance upstream from the tagging site at Scandinavian Slough. Initial tests for violations of equal probability of capture throughout the first and second event will be based on second event data collected at the weir sites and on the spawning grounds. After the initial tests are performed, secondary tests will include data from the inriver sonar assessment. If initial and secondary tests indicate no evidence of capture heterogeneity during the first sampling event, all second event data will be used to estimate abundance. If initial tests detect no evidence of capture heterogeneity during the first event, but the secondary tests detect significant differences in marked to unmarked ratios between the weirs we may conclude sampling bias occurred during the inriver fisheries due to lack of detection of marks or differential probability of capture between marked and unmarked fish in one or both fisheries.

Remedial measures for these sources of bias include complete censoring of data from a biased source and, where applicable, reducing the effective number of marked fish in the experiment by subtracting marks removed from the commercial, sport and subsistence fisheries. This must be done prior to calculating the mark-recapture estimate

Appendix A2.– Detection of size and/or selective sampling during a two-sample mark recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis (Chi^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two sample test (e.g. Student's t-test).

M vs. R	**C vs. R**	**M vs. C**
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o

There is no size/sex selectivity detected during either sampling event.

Case II:

Reject H_o	Fail to reject H_o	Reject H_o

There is no size/sex selectivity detected during the first event but there is during the second event sampling.

Case III:

Fail to reject H_o	Reject H_o	Reject H_o

There is no size/sex selectivity detected during the second event but there is during the first event sampling.

Case IV:

Reject H_o	Reject H_o	Either result possible

There is size/sex selectivity detected during both the first and second sampling events.

Evaluation Required:

Fail to reject H_o	Fail to reject H_o	Reject H_o

-continued-

Sample sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the first event which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), the rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must

first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

-continued-

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameters (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \text{; and,} \quad (1)$$

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \sum_{i=1}^{j} \left(\hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + (\hat{p}_{ik} - \hat{p}_k)^2 \hat{V}[\hat{N}_i] \right). \qquad (2)$$

where: j = the number of sex/size strata;

$\hat{p}_{ik}$ = the estimated proportion of fish that were age or size k among fish in stratum i;

$\hat{N}_i$ = the estimated abundance in stratum i; and,

$\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.

Appendix A3.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

1. Marked fish mix completely with unmarked fish between events;
2. Every fish has an equal probability of being captured and marked during event 1; or,
3. Every fish has an equal probability of being captured and examined during event 2.

To evaluate these three assumptions, the chi-square statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all three tests are rejected, a temporally or geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

I.-Test For Complete Mixing[a]

Area/Time	Area/Time Where Recaptured				Not
Where	**1**	**2**	**…**	**t**	$(n_1\text{-}m_2)$
1					
2					
…					
s					

II.-Test For Equal Probability of capture during the first event[b]

	Area/Time Where Examined			
	1	**2**	**…**	**t**
Marked (m_2)				
Unmarked $(n_2\text{-}m_2)$				

III.-Test for equal probability of capture during the second event[c]

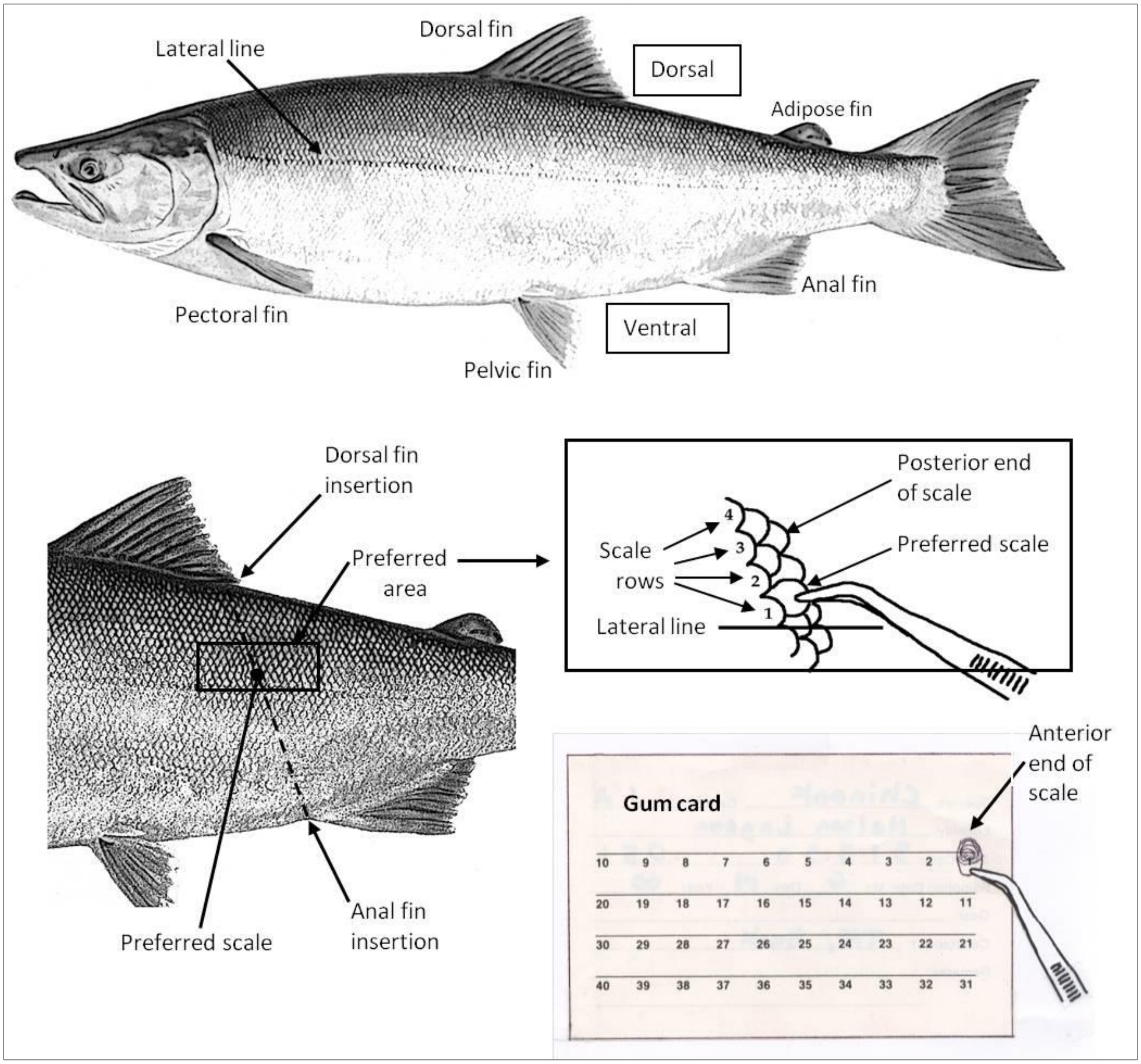
	Area/Time Where Marked			
	1	**2**	**…**	**s**
Recaptured (m_2)				
Not Recaptured $(n_1\text{-}$				

[a] This tests the hypothesis that movement probabilities (θ) from time or area *i* (*i* = 1, 2, ...s) to section *j* (*j* = 1, 2, ...t) are the same among sections: H_0: $\theta_{ij} = \theta_j$.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among time or area designations: H_0: $\Sigma_i a_i\theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum *j* at the time of sampling, and a_i = number of marked fish released in stratum *i*.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among time or area designations: H_0: $\Sigma_j\theta_{ij}p_j = d$, where p_j is the probability of capturing a fish in section *j* during the second event, and d is a constant.

Appendix A4.–Preferred (left side) scale sampling area on an adult salmon.

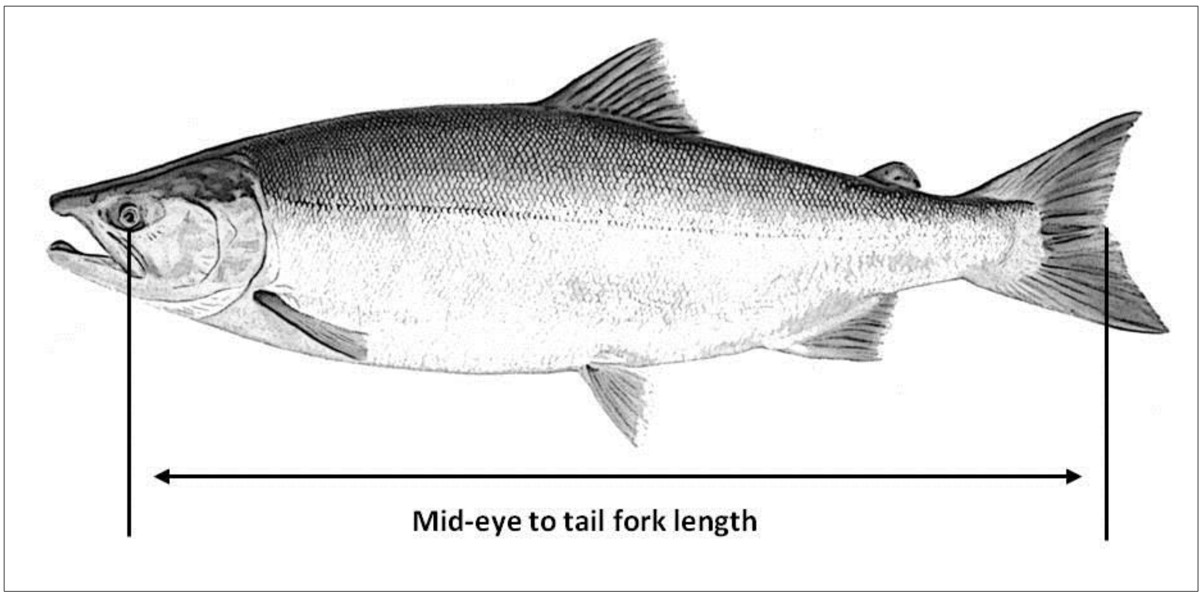


Do not turn scale over (ridged side should face up, as on fish). Place scales directly over the number on the gum card. Mount scale with anterior portion of scale oriented toward the top of the card, posterior end toward the bottom.

Appendix A5.–Measuring length of an adult salmon.

The procedure for measuring mid-eye to fork of tail length is as follows:

1. Place the salmon flat, right side down, on a board that has a ruler mounted on it with a metric scale. Orient the salmon with its head on your right, the tail in your left hand, and the salmon's dorsal surface (back) towards you. This puts the salmon in the correct orientation to remove the preferred scale from the fish's left side if the scaler is standing on the other side of the measuring board.
2. Line the eye of the salmon up with the end of the ruler, hold the salmon's head with your right hand. Gently sliding your thumb into the salmon's mouth and grasping the lower jaw works well for larger fish.
3. Flatten and spread the tail against the board with your left hand. Read the mid-eye to tail fork length to the nearest 5 millimeter and record sex and length on ASL form.



Appendix A6.–Weir sampling form.

Date		Chinook (410)					Sockeye (420)	Coho (430)	Chum (440)	Chum (450)		Rainbow	Graylord	Southern Pike		Stream Conditions				Boats	Rafts	Notes
Day	Date	Count	Harvest	Scales	# F	Genetics	Count	Count	Count	Count		Count	Count	Count		Water Stg.	AM Temp	PM Temp	Clarity			

Appendix A7.–Spawning ground sampling form.

Date	Gear	Sex	Left Upper Opercular Punch (LOUP) Y/N	Left Axillary Clip (LAA) Y/N	Adipose Clip Y/N	Scale Card No	Scale Number	Length MEF	Size Class (S, M, L)	Pre/Mid/Post	A/M/C	Comments (eg. Tag #, Secondary Marking)

Non-lethal Sampling Finfish Tissue for DNA Analysis

ADF&G Gene Conservation Lab, Anchorage

I. General Information

We use axillary tissue samples from individual fish to determine the genetic characteristics and profile of a particular run or stock of fish. The most important thing to remember in collecting samples is that only quality tissue samples give quality results. If sampling from carcasses: tissues need to be as "fresh" and as cold as possible and recently moribund, do not sample from fungal fins.

Sample preservative: Ethanol (EtOH) preserves tissues for later DNA extraction without having to store frozen tissues. Avoid extended contact with skin.

II. Sample procedure:

1. Tissue type: Axillary process; clip one axillary process from each fish (see attached print out).

2. Prior to sampling, fill the tubes half way with EtOH. Fill only the tubes that you will use for a particular sampling period. The squirt bottle is for day use only since it will leak if unattended.

3. To avoid any excess water or fish slime in the vial, wipe the axillary process dry prior to sampling. Using the dog toe nail clipper or scissors, clip off axillary process (**1/2 -1" max**) to fit into the cryovial.

4. Place axillary process into EtOH. The ethanol/tissue ratio should be **slightly less than 3:1** to thoroughly soak the tissue in the buffer.

5. Top up tubes with EtOH and screw cap on securely. Invert tube twice to mix EtOH and tissue. Periodically, wipe or rinse the clippers so not to cross contaminate samples.

6. Data to record: Record each vial number to **paired data** information, electronic copy preferred.

7. Discard remaining ethanol from the 500ml bottles before shipping. **Tissue samples must remain in 2ml ethanol**, these small quantities require HAZMAT paperwork. Please follow packing instructions for HAZMAT items. Store vials containing tissues at room temperature, but away from heat. In the field: keep samples out of direct sun, rain and store capped vials in a dry, cool location. Freezing not required.

III. Supplies included with sampling kit:

1. Clippers - used for cutting the axillary process.
2. Cryovial - 2.0ml pre-labeled plastic vial or tube.
3. Caps – cap for each vial.
4. Sampling rack- plastic box for holding cryovials during sampling.
5. Ethanol (EtOH) – in Nalgene bottle(s).
6. Squirt bottle – to fill and/or "top off" each cryovial with EtOH
7. Sampling instructions
8. Laminated "return address" labels

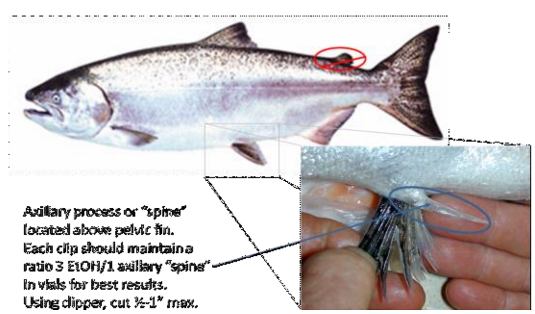
IV. Shipping: HAZMAT paperwork is required for return shipment of these samples and is included in the kit.

Return shipping code: ___________________

Ship samples to:

ADF&G – Genetics
333 Raspberry Road
Anchorage, Alaska 99518

Lab staff: 1-907-267-2247
Judy Berger: 1-907-267-2175



APPENDIX B: ACCOUSTIC TAG OPERATION PLAN

NUSHAGAK ACOUSTIC TAG STUDY FIELD OPERATION PLAN

Principal Investigator: Suzanne Maxwell, Sonar Coordinator

Co-Principal Investigator: Greg Buck, Nushagak Project Leader

Other Personnel:

Acoustic Tag Sales and Training Staff

Henry Tam, Lotek Sales Representative

3-Dimensional Data Reduction and Analyses

Anna-Maria Mueller, Aquacoustics, Inc.

Don Degan, Aquacoustics, Inc.

Xinxian Zhang, Biometrician

Acoustic Tag Detection

Suzanne Maxwell

Greg Buck

April Faulkner

Acoustic Tag Application

Vacant, Fishery Biologist I

Vacant 1, Fish and Wildlife Technician II

Vacant 2, Fish and Wildlife Technician II

Vacant 3, Fish and Wildlife Technician II

Vacant 4, Fish and Wildlife Technician II

Nushagak Sonar Operations

Greg Buck, Project Leader

Konrad Mittlestadt, Sonar Crew Leader

Hannah Hilowitz, Fish and Wildlife Technician II

Randy Guintu, Fish and Wildlife Technician II

Mariel Terry, Fish and Wildlife Technician II

Tyler Henegan, Fish and Wildlife Technician II

Eric Gorman, Fish and Wildlife Technician II

INTRODUCTION

The Nushagak River supports one of the largest Chinook salmon (*Oncorhynchus tshawytscha)* runs in the state of Alaska. These salmon are harvested by subsistence and sport users all along the river and by commercial and subsistence fishermen in Nushagak Bay. The salmon are both a dietary staple for subsistence fishermen and their families and an important economic resource for commercial fishermen and sport fishing guides. The primary tool fishery managers use for assessing the run is a sonar project located near the village of Portage Creek. The sonar project was designed to estimate sockeye salmon, which migrate close to shore in strong current, and not Chinook salmon. Larger Chinook salmon are capable of migrating farther offshore, and an unknown proportion travel outside the sonar's coverage.

This project is designed to determine the accuracy of the sonar project's Chinook salmon inriver estimates and recommend ways to improve the sonar estimates. The sonar project uses sonar systems to assess fish passage combined with test fishing to apportion the sonar counts into species-specific counts. At the project site, the Nushagak River is approximately 300 m wide. A dual-frequency identification sonar (DIDSON) ensonifies a section of river extending from nearshore to 50 m offshore of the right bank (facing downriver) and 30 m offshore of the left bank, less than 27% of the river's width. It is unknown what proportion of the Chinook salmon pass outside the ensonified sections of the river. A drift gillnet study conducted at stations encompassing the entire river showed that sockeye salmon (*O. nerka)* passed mostly within the sonar's range, whereas Chinook salmon migrated within these same regions as well as farther offshore. Although the sonar project is not designed to assess Chinook salmon, the apportionment process produces estimates for Chinook salmon, which have been integrated into and become an important part of commercial and sport fish management. The Nushagak-Mulchatna King Salmon Management Plan (5 AAC 06.361) includes management actions based on Chinook salmon inriver estimates from the sonar project.

To successfully manage for escapement, sustainable escapement goals must be established, and the escapement must be monitored with enough accuracy and precision to ensure the goals are met. The Nushagak inriver goal of 95,000 Chinook is designed to

provide 55,000 fish for spawning escapement and 10,000 fish for subsistence and sport fish harvests upriver of the assessment site. If the inriver abundance is projected below 95,000 fish, the Nushagak-Mulchatna King Salmon Management Plan (5 AAC 06.361) calls for restrictions to commercial and sport fish fisheries; if projected inriver abundance falls below 75,000 fish, the subsistence harvest is restricted. The numbers of fish used as triggers in the management plan are based on escapement estimates generated by the Nushagak River sonar project. These estimates may not be an accurate estimation of Chinook salmon abundance.

Acoustic tags are often used to track fish in marine or riverine environments because sound propagates well in water. These tags consist of small transmitters inserted or surgically implanted into fish, which when detected by a series of fixed hydrophones can be used to track the fish movement. A primary use of this technology has been to track salmon smolt movements in three spatial dimensions within the vicinity of hydropower turbines or during outmigration. Larger fish such as adult lingcod (*Ophiodon elongatus)* and salmon have also been tracked using this technology. Previous research tested acoustic tags in the Kenai River to determine the effective range of the hydrophones and found that tags were detectable at every point across the river and in tracks reaching 160 m upriver and 280 m downriver of hydrophones placed nearshore along both sides of the river.

For this project, four-dimensional spatiotemporal information will be obtained from acoustically tagged Chinook salmon as they migrate past the sonar site. With this information it will be possible to determine whether a given tagged fish is within the range of the DIDSON and has been detected by it. This detection probability will be used to expand the DIDSON-based estimate to an estimate of the total number of Chinook salmon in the river.

Bathymetry and current flow information will also be collected to gain a better understanding of the factors that might influence the migration corridors used by Chinook salmon. The relationship between bathymetry, flow, and fish migration patterns will be used to improve the sonar and test fish operations of the Nushagak River sonar project.

OBJECTIVES

Improve Chinook salmon escapement estimates in the Nushagak River.

a. Determine the proportion of migrating Chinook salmon outside the range of the DIDSON, and use that proportion to expand the DIDSON-based count such that the inriver abundance estimates are within 20% of the true value 95% of the time.

STUDY SITE

The Nushagak River sonar site is located approximately 53 km (33 mi) upstream from the terminus of the Nushagak commercial fishing district near the village of Portage Creek and 5 km (2.5 mi) downstream from the village of Portage Creek. At the site, the river is a single channel approximately 300 m wide. Although the site is within tidal influence and a reduction in flow occurs at high tide, there is rarely a reversal of flow and there appears to be very few fish milling in the area.

Tagging will be conducted using 6 in and 8 1/8 in gillnets at a site approximately 7.0 miles downriver from the sonar site. Although it was our intention for the site to be as far downriver as possible to allow salmon to return to their normal migration behavior after handling and before reaching the sonar site, regions farther downriver were poor fishing areas because of the large channel, numerous sand bars, and high winds. Criteria considered for the tag insertion site included maximum distance from the sonar site, channelization, concentrations of sport anglers, tidal affect, and obstructions. A compromise was made when we selected a site where the river is divided into 2 channels. In 2010, a location within each channel was selected (Figure 1), and both were successfully fished with drift gillnets, one on the main river channel and one on a smaller, side channel. Both sites proved suitable for capturing and tagging Chinook salmon and will be used in subsequent years of the study.

METHODS

Sample Size

Assuming a Chinook salmon run of 200,000 and that the sonar counts 50% of the fish, a sample size of 200 tagged fish will have a 95% chance or probability that the estimated inriver abundance will not differ from the true abundance by more than 20%. (Seber 1982, pages 64-69, Xinxian Zhang, Regional Biometrician, ADF&G, Anchorage, personal communication).

Data Loggers

Deployment

An array of seven LOTEK Data loggers (DLs) will be deployed near the shoreline in water 1-2 m deep in a manner designed to track tagged fish from just below the north bank sonar to just above the south bank sonar; a distance of approximately 250 m. The DLs will be mounted upside down on the metal tripods custom built for this purpose using a sleeve bracket that slides over the upright post of the mount. A stop prevents the DL from touching the base of the tripod when sliding it over the upright post. Loggers will be mounted to the tripod with the black antenna hydrophone component pointed downward. The sleeve bracket holding the DLs can be moved up and down the post raising or lowering as needed to ensure the hydrophone antenna is approximately 0.5 m from the river bottom when the assembly is deployed. Tripod and DL assemblies should be deployed so that the DL is as vertical as possible in the water column. Red ball buoys will be attached to each tripod mount to mark the tripod's location and alert boat operators to its presence. All tripod/DL assemblies should be deployed with a 25 m data cable attached to the DL so that laptops can be connected to the DL and data downloaded or performance checked without disturbing the deployment of the DL. Ideally, all 7 DLs in the array will be deployed at the same time so that battery usage over the course of the season is similar between DLs. The array will be operational from approximately **June 8 through July 18**.

Moving DLs has a negative impact on the processing of data. Therefore, deployments will be made to minimize disturbances to the hydrophones. Loggers should be far enough offshore that they will not have to be moved often if/when the river level drops while at the same time not so far offshore that tagged fish are likely to swim between DLs and the shore which makes tracking tagged fish more challenging. Three DLs will be deployed on the south bank and 4 on the north bank at approximately equidistant points. The most upriver deployment on the south side will be approximately 10 m upriver from the DIDSON deployment and far enough offshore that it will be relatively unobstructed by the weir. The farthest downriver deployment will be directly across the river from the farthest downriver deployment on the north bank which will be directly below the sonar camp. The farthest upriver deployment on the north side will be directly across from the farthest upriver deployment on the south side.

Data logger and array Testing

We will set a stationary tag for 1 h (or more) at 6 test positions and estimate the positions by exporting data from all DLs and running ALPS in order to test the performance of the array. The exported data will be examined from the viewpoint of each beacon and plotted to determine the accuracy of the position estimate. A second test will be conducted by drifting a tag through the array near each bank and down the middle several times and then downloading all DLs and running ALPS to test the efficacy of the array at building fish tracks at all locations that we desire coverage. Data loggers will be redeployed and the array retested if necessary. Tagging will commence once the array is satisfactorily deployed.

Data Collection and array performance monitoring

Loggers will be deployed with data cables attached. This allows the monitoring of data collection and battery level without disturbing the DL. One DL will be designated as a proxy for all DLs when the array is deployed and used to monitor the performance of the array as well as

DL battery levels on a weekly basis during deployment. This monitoring and downloads will be accomplished using a 25-m cable and laptop running LOTEK software.

Loggers use an 8 v battery pack which should last an entire deployment cycle (season). If battery levels fall below 6-volts, all DL batteries should be changed at the next low tide. Additionally, these intermediate downloads will be used to estimate the number of tags that the array has encountered which will give us some assurance that our tagging operation is not producing an unacceptable number of fish that fail to reach the sonar site.

All inseason data downloading will be done without interrupting the data collection. When all DLs are removed from the water at the end of the deployment a final download will be done that will encompass all the entire season. This is the data file that will be used for analysis. Once this file has been secured the DL should be wiped of data in preparation for the following season, cleaned and the battery removed for winter storage.

Data processing will be done post-season. Lotek 'bin' files will be processed using the latest version of ALPS to obtain position estimates for the detected tags. Text files exported from ALPS will be concatenated by tag number and imported into R for processing tasks and parameter filtering can be explored. Final tracks will be imported into ArcGIS and combined with bathymetry, velocity and temperature data.

DIDSON Sampling and Sonar Test Fishing Program

Sockeye and king salmon escapement at the Nushagak River is estimated using sonar and test fishing operations will be conducted according to existing project operational plans with the following additions: 1) an additional 15 m DIDSON file is recorded in each counting strata that will not be used for escapement estimation but will be used in an attempt to capture tagged fish on the DIDSON, and 2) latitude and longitude coordinates will be documented for each DIDSON position upon initial deployment and all subsequent adjustments.

The Ashtech GPS running Mobile Mapper software will be used to record lat/long coordinates for each DIDSON position, This will be recorded in the relevant DIDSON logbook. DIDSON beam coverage will be estimated using unit specifications and operating parameters.

Bathymetry and Current Velocity

Ice jams and flood events can alter the river bottom topography at the sonar site and river velocity is influenced by tide and river level. In order to get as accurate a picture of these environmental variables, we will collect velocity and depth data using a SonTek M9 River Surveyor acoustic doppler current profiler (ADCP) several times each season. Each data collection event will consist of 6 transects; 2 conducted at 3 locations. One transect will be established just down river of the north bank DIDSON. One transect will be established immediately upriver of the south bank DIDSON and the third transect will be equidistant between the other two. Bathymetry and velocity data collected will be used to develop 3-dimensional maps of the sonar site upon which we can map tagged fish.

Communications and Quality Control

A daily count of the number of tags deployed will be kept in the sonar tent. A weekly count of the number of tags detected on the proxy DL will be kept in the sonar tent.

Accoustic Tagging

A base of operations for the tagging crew will be established as near the tagging site as possible and approved by Choggiung Inc. An acoustic tagging crew of 2 technicians will operate from this camp. A tagging goal of **200 tags per year** is established. Careful attention will be paid to the training of the Technicians assigned to this task and this training will include the removal of fish from nets, measuring length, inserting tags, and the recovery and release of fish in a manner that *minimizes stress* of the fish.

Fishing Zones

During fishing operations between 2010 and 2013, the crew has established 3 zones in the main channel and 1 zone in the small channel for a total of 4 zones:

Zone 1 – right bank nearshore (RBNS)

Zone 2 – mid-river (MR)

Zone 3 – left bank nearshore (LBNS)

Zone 4 - back channel (BC)

The measured depths of these zones were: RBNS 18-23 ft; MR 12-15 ft, and LBNS 5-10 ft. Bathymetry data of the zones were collected in 2011. We anticipate using these same zones in 2014-2016 unless significant changes are detected in the river bottom topography.

Gillnets

The gillnets used in accoustic tagging are identical to two of the nets used for apportionment in the sonar operations. The only net size used for sonar apportionment that is not also used by the accoustic tagging crew is the 5 1/8 in mech as it is not very effective for most king sizes encounted in the Nushagak River. Net specifications and fishing sites are chosen to ensure the whole water column is fished.

Tagging

Acoustic tags will be stored with the magnet taped in place (in the condition in which they are shipped). Tags to be used each day will be tested in the morning in camp prior to fishing. This is done by removing the magnet (activating the tag) and using a Map RT-A unit to detect the tag. Tags that cannot be detected will not be deployed. At the end of the day, magnets will be replaced on any tags that not applied that day in order to conserve the tag battery will be hooked up to a computer, and the tag will be read by the unit. All tags for a single day will have their magnets removed prior to the start of the first drift period.

Captured fish will be placed in a holding tank and measured for total length (TL – end of snout to tail fork) and mid-eye to tail fork length (METF). An acoustic tag was inserted into the esophagus, and a genetic sample was taken. The METF length measurement is a more common measure and is the one used at the sonar project; TL measurements more closely approximate length measurements made from DIDSON images and will be used to assist us in identifying a tagged fish if multiple fish are passing at a similar time and range. A Floy tag will be attached to each fish to identify recaptures and alert fishermen to tagged fish. The same sampling guidelines from 2011 will be adhered to in 2012:

The following checklist will be followed when capturing subject fish:

- Nets will be pulled as soon as corks dip, we will strive for no more than 1-2 fish in the net at a time.
- Fish will be placed in the live box, i.e., a container filled with river water, as quickly as possible. The water will be changed frequently to prevent losing oxygen and damaging fish.
- All handling of fish will be done within the live box.
- Prior to handling, the tech will run a hand down the fish's lateral line with a fair amount of pressure to calm the fish.
- Tags will be carefully inserted into the esophagus.
- Each fish will be measured for TL and METF and a scale sample will be collected.
- If a captured fish is bloody or looks stressed or damaged, it will be released without applying a tag; erring on the side of caution.
- A tagging crew of 3 is recommended, 2 to apply tags and manage nets and 1 to drive the boat.
- A Floy tag will be attached to each fish to identify re-captured fish.
- If a previously tagged fish is recaptured at either the lower river test fish site or the sonar site, rather than releasing a twice-stressed fish, we will extract the tag and apply it to a newly captured fish.

Fishing effort will be divided into 2 periods per day. Because drifting gillnets is less effective on an incoming tide or if the current is stagnant, fishing periods will be centered on ebb tide. Additional fishing periods may be designated if tagging falls behind schedule. The suggested tag application schedule is designed to evenly spread the tags across the run and is shown below:

Table 1. Suggested fishing schedule.

			PERIOD 1			PERIOD 2		
Date	Day	Zone Order	Mesh	Fish Zn 4?	Tags	Mesh	Fish Zn 4?	Tags
06/13	1	1,2,3	s	n	1	l	y	1
06/14	2	3,1,2	l	y	1	s	n	1
06/15	3	1,3,2	s	n	2	l	y	2
06/16	4	2,3,1	l	y	3	s	n	2
06/17	OFF							
06/18	5	1,3,2	s	n	3	l	y	3
06/19	6	1,3,2	l	y	4	s	n	3
06/20	1	1,3,2	s	n	5	l	y	4
06/21	2	2,3,1	l	y	5	s	n	5
06/22	3	1,2,3	s	n	5	l	y	5
06/23	4	1,3,2	l	y	5	s	n	5
06/24	OFF							
06/25	5	2,1,3	s	n	5	l	y	5
06/26	6	1,3,2	l	y	5	s	n	5
06/27	1	2,1,3	s	n	5	l	y	5
06/28	2	1,2,3	l	y	5	s	n	5
06/29	3	3,2,1	s	n	5	l	y	5
06/30	4	1,2,3	l	y	5	s	n	5
07/01	OFF							
07/02	5	2,3,1	s	n	5	l	y	5
07/03	6	2,3,1	l	y	5	s	n	5
07/04	1	3,1,2	s	n	3	l	y	3
07/05	2	2,1,3	l	y	3	s	n	3
07/06	3	3,1,2	s	n	3	l	y	3
07/07	4	1,3,2	l	y	3	s	n	3
07/08	OFF							
07/09	5	3,1,2	s	n	3	l	y	3
07/10	6	2,3,1	l	y	3	s	n	3
07/11	1	3,2,1	s	n	2	l	y	2
07/12	2	1,2,3	l	y	2	s	n	2
07/13	3	1,2,3	s	n	2	l	y	2
07/14	4	2,1,3	l	y	2	s	n	2

This schedule should allow at least 4 days of detection time for tagged fish to reach the sonar site before the DLs are removed from the river. Although it is assumed fish will travel from the fishing site to sonar site within 1-2 days, because of the expense of the tags, we will stop fishing earlier to improve the detection odds of fish tagged toward the end of the study.

Data Recording and Communications

Data collected on each captured fish will be recorded onto paper datasheets or electronic data logger and include the following for each tagged fish:

1. Acoustic tag number
2. Floy tag number
3. Date tag inserted
4. Drift start time
5. Drift end time
6. Zone
7. Mesh size
8. TL (cm)
9. METF (cm)
10. Scale sample
11. Fish condition
12. Dry Tag Check (checkbox)
13. Wet Tag Check (checkbox and direction)
14.

Data Analysis

A sample size of 200 tagged fish will have a 95% chance or probability that the estimated inriver abundance will not differ from the true abundance by more than 20%. (Seber 1982, pages 64-69).

RESPONSIBILITIES

Buck, Principal Investigator (assisted by vacant FB I crew leader), will

1. direct project operations
2. provide general supervision for the project
3. assist with the logistics of data collection and processing
4. be responsible for the final products including articles, reports, and presentations
5. provide detailed written instructions for the tag detection technician and fishing crews
6. train test fish crew on use of MAP RT-A unit
7. outline tag insertion methods for the crew
8. assist with ADCP surveys in June
9. take pictures and videos of operations
10. direct operations related to the Nushagak River sonar project
11. replace DL batteries and download data mid-season
12. provide logistical support for the grant project
13. assist with data collection, analyses, and publication
14. hire and evaluate the tag detection technician
15. take Degan and Mueller to the test fishing site for bathymetry work
16. assist Degan and Mueller with ADCP and bathymetry surveys in July

17. assist with training test fish crew on use of MAP RT-A unit
18. assist with training test fish crew on tag insertions
19. take pictures and videos of operations
20. write a field season summary (see methods)

Faulkner, Assistant Sonar Coordinator, will

1. direct the setup of the DIDSON units
2. learn all aspects of the tagging operations and be prepared to assist with training in subsequent years
3. assist with writing detailed instructions for all crews
4. assist with the ADCP surveys in June

Vacant, Netting Coordinator, will

1. hire and supervise the netting crew
2. provide a suitable boat and nets for the fishing operations
3. provide supplies and handle logistics for the netting crew
4. produce and distribute a handout for fishermen to describe the tagging project and instructions on what to do if they capture a tagged fish
5. write a field season summary (see methods)

Sisak, Lotek staff, will

1. assist with the purchasing of equipment
2. provide oversight for site assessment and placement of equipment
3. train ADF&G staff in the use of all acoustic tag equipment
4. provide technical support as needed in the use of this equipment

Degan and Mueller, Aquacoustic's Inc. staff, will

1. travel to the site to do the July ADCP survey and bathymetry surveys at the sonar and lower river fishing sites
2. produce bathymetry files that are ArcView compatible
3. provide technical support in the use of the bathymetry and ADCP data
4. provide 3-d analyses of the data
5. assist with report writing and publication

Sonar Crew, Tag Detection technician, will

1. assist with deploying DLs
2. become proficient in the use of MapHost software
3. monitor DLs daily for water level
4. download data daily from the wired DL
5. process data using WHS Reader daily to determine which tags have been detected
6. communicate daily to test fishing crew regarding tags applied and detected
7. error check paper and electronic datasheets weekly from test fishing crew
8. search DIDSON files for tagged fish
9. copy all DIDSON files containing tagged fish to an external drive containing the acoustic data

Sonar Crew will

1. collect all DIDSON data and count fish in images

2. provide files for the tag detection technician as needed
3. backup all DIDSON files including the extended ones

Test fish Crew will

1. fish gillnets at lower site according to the fishing schedule in Table 2 and methods in Tag Insertion section
2. measure and record data on fish
3. apply acoustic and floy tags
4. transfer data from paper datasheets to electronic spreadsheets
5. error check data (paper and electronic)
6. transmit tag information daily to sonar site
7. deliver electronic and paper datasheets weekly to sonar site

Zhang and Fair will provide biometric and editorial support for reports and papers.

APPENDIX C:
GENERAL FIELD CAMP POLICY

EQUIPMENT MAINTENANCE

Equipment maintenance is one of the most important operations performed during the field season. The outboard motors, generators, and other equipment must be kept in good operating condition.

It will be the crew leader's responsibility to see that all equipment is kept in good operating condition.

ENGINE CARE AND OUTBOARD OPERATION

If outboard uses mixed fuel, the correct outboard motor fuel mixture is 50:1. The newer Precision Blend outboards mix the 2-cycle oil and gas automatically, but older engines will need to have their fuels pre-mixed. Always pour the oil into the tank first, then add 2 or 3 gallons of gas and mix thoroughly, then fill tank to capacity always using a large funnel and filter. Some outboards may be 4-stroke engines, which need to have oil level checked routinely. Always mix fuel tanks or equipment under cover to prevent water contamination and always use a funnel and filter. Note that some chainsaws have a fuel mixture of 25:1, but some newer models (e.g., Stihls) use a 50:1 mix. Chainsaw gas should be mixed in a separate can and clearly marked that it is chainsaw fuel to avoid accidentally being used in outboards.

Always place outboard motors in neutral when starting and always make sure a safety line is attached between the boat and motor. Perform a check daily of the clamp screws “dog ears” that hold the outboard to the transom. Also routinely check the motor for loose screws and bolts, cracks, and breaks, especially in the area of the lower unit.

In the normal operation of an outboard, a stream of water is discharged from a hole in the bottom edge of the cowling or from the back of the shaft. If this stream of water stops, the water pump may not be working and the motor should be shut off. On propeller outboards, the side plate over the water intake can be removed for cleaning as it may be plugged. If the pump continues not to function, the outboard should not be run, and a report to base camp should be made. On jet units, a cover on the side of the cylinder head through which water circulates can be removed and cleaned, and the cover over the temperature sensor (thermostat) can also be cleaned to restore flow. Take along a piece of bailing wire to dislodge sand from the small water discharge tube under the cowling.

Check the gear oil in the lower unit of the outboard once a week and drain and replace the gear oil at the end of the season and every 50 hours of operation. Jet units must be greased daily. This is crucial. Grease guns will be provided.

If the prop, skeg or jet unit hits bottom, check the screws to make sure they are still secure and there is no damage to the lower unit. Also, remove any rocks stuck between the grates on the jet unit.

All outboards are to be tilted in the up position when moored to preclude silt accumulation in the jet unit or water pump and skeg or housing damage.

-continued-

If your outboard will not start, check the following:

- Check to make sure the kill switch is clipped to the engine properly.
- Check to see if the fuel line is connected properly to the motor and the tank and not pinched or kinked, and that the air vent on the tank is open.
- Check to see if there is water in the gasoline.
- If the engine is flooded, wait 5 minutes for the plugs to dry before attempting to start again.
- Check the spark plugs and spark plug wires as they may be fouled or defective (replace if needed).

BOATS

Boats are to be kept clean and free of loose tools and debris, and moored at locations where they are not subject to damage by other traffic or through contact with the river bottom in rock laden areas. Boats must be bailed regularly of rainwater to keep them from sinking.

Further responsibility includes maintaining a bow line on each assigned craft and ensuring that each boat is properly moored at the end of each work day to preclude possible loss or damage.

GENERATORS

Portable generators may be supplied to field camps. Their maintenance is important. Since most of the generators have 4-cycle engines, mixed gas must not be used. The crankcase oil reservoir should be checked daily and maintained at the full level. At the end of the season, and after 25 hours of operation, the oil should be changed. Spark plugs should be checked at every oil change for fouling and gap.

CAMP MAINTENANCE

Keep the cabin, surrounding area, and yourself clean and neat. Appearance is important. You will not always be notified of the intended arrival of visitors, officials, etc. Visitor impressions are often based on your appearance.

Maintaining a clean and efficient field camp is required. Maintenance of living accommodations and other installations will be performed as necessary. All materials necessary will be provided.

Grounds will be kept free of litter. All garbage will be burned or bagged up and disposed of in town. Special precautions should be observed to ensure that garbage does not attract bears and other scavenger species. Dirty dishes should be washed daily and kept inside the cabin, not left in the yard or outdoors where it will attract bears.

Upon completion of the summer season, all camp equipment will be cleaned prior to winter storage. All sampling nets, tarps and life jackets must be dry before being stored. All skiffs will be brought back to the ADF&G compound.

The crew leader at the close of the field season will take a complete equipment inventory. A report detailing the equipment and storage locations will be submitted at the end of the season to the supervisor. A list of equipment needing replacement or repair will also be submitted, along with an equipment need list for next season.

-continued-

CAMP POLICY

No alcoholic beverages are to be stored in areas open to public view. If alcohol is consumed at a camp an employee must be of legal age and off duty and under no circumstances shall he or she engage in the operation of any State equipment or firearms. Employees will not return to duty status under the influence of alcohol.

The crew leader of each camp shall establish a policy on living standards and personnel behavior in accordance with State guidelines. Time off for individual crew members must be scheduled by the supervisor. All employees will be required to act in a professional manner at all times and shall be especially courteous to the public.

It will be the responsibility of the crew leader to prevent any abuse of State equipment. The crew leader will report within 24 hours to the supervisor any damaged or lost equipment.

FOOD ORDERS

ADF&G will provide all food and non-alcoholic beverages while working in the field. Groceries will be purchased by either the field crew when in town or by available office personnel. It is useful to keep an on-going grocery list so you know what is needed or not needed since fridge and freezer space is limited.

COMMUNICATION

One or two phones will be available in camp. A satellite phone will primarily be used to communicate data with Dillingham or project staff.

Scheduled calls are used to pass on pertinent information to/from the field offices. It is expected that all employees will participate in these schedules to get familiar with the procedure. The morning schedule is used for relaying the daily species count and high priority business only as the Dillingham office personnel attempt to get counts from all field camps at the same time. Keep the conversations short so we do not hold up others using the same channel. The bettors phone may be used for personal calls using a calling card. The track phone is not to be used for personal use without permission and all personal calls must be logged.

Any employees performing job duties away from the field camp (such as boating trips up/downriver) or hiking/sport fishing/etc. on their own time are required to let others know their plans such as where they are going and when they are expected to return. Also, in each camp is a handheld VHF radio (with spare batteries), backpack with basic survival gear, and firearms and ammunition which the employee is encouraged to carry for their own safety. All employees should be aware of the gear in the camp and should request additional safety/survival items if needed or missing. Employees with any questions or concerns are asked to pass them on to their supervisor.

-continued-

FIREARMS

A State firearm will be provided at this field camp. If you are unfamiliar with the operation and use of a firearm, please let your supervisor or the crew leader know. Training will be provided for anyone who requests it or is unfamiliar with firearms. Loaded guns are prohibited inside the camp facilities. Anyone handling a firearm should always treat it as if it were loaded. Guns should be kept clean and oiled daily if used and at the end of the project. Any horseplay or misuse of firearms while working for the Department of Fish and Game will not be tolerated and may be grounds for immediate dismissal. Completely unload a firearm of all rounds before cleaning or transporting back to town.

BEARS

Do not encourage bears to come around camp by leaving food or unburned garbage around. Do not shoot at a bear unless, in your best judgment, it is endangering someone's life or damaging personal or state property. Use your best judgment on whether to shoot a bear if property is at stake. When trying to frighten a bear away by shooting, do not fire toward it. You may wound it by pulling the shot, ricochets, etc. Do not use cracker shells at close distance (<30’). If a cracker shell hits a bear at close range, it may penetrate the body cavity and explode inside the bear, killing it.

GARBAGE

Burn garbage as needed, and box up any non-burnable trash to haul back to town. Be sure all burn barrels have proper grates or covers to prevent grass fires from sparks. Never leave a fire unattended and always have adequate fire extinguishing materials handy. Food that is discarded should be contained in a “slop bucket” inside the cabin. As needed, the bucket can be then be dumped into the river downstream of the weir. This should be done in the evenings when there are no sport fishermen down river.

FISH AND WILDLIFE VIOLATIONS

This is not intended as an inclusive procedure for handling violations. Below are guidelines for obtaining the necessary information and/or evidence to document a violation. It is important to be familiar with the commercial fishing, subsistence fishing, sport fishing, and hunting regulations in your area. Violation reporting procedures are printed on the back cover of the commercial fishing regulation book. Request the regulation book if your camp does not have one.

The use of the “4 Ws” can greatly aid the Fish & Wildlife Protection officer in obtaining sufficient evidence for a case.

- What is the violation?
- When did the violation occur (e.g., date, time, tide condition, etc.)?
- Where did the violation occur?
- Who is in violation and who are witnesses?

-continued-

It is important that specifics about the event be documented so the appropriate officer can follow-up and contact those involved. If you have a camera available, pictures are extremely valuable in prosecuting offenders. Collect as much information as possible and contact your supervisor or a State Trooper from the Alaska Wildlife Troopers Division immediately. If you do not feel comfortable, or your personal safety may be in danger, do not pursue the violation. Contact your supervisor and they will handle the situation. Be aware that you do not have the power to arrest somebody or seize equipment. Just limit yourself to documenting the event as safely as possible.

TRANSPORTATION

Do not endanger life or property by using the skiff rough water conditions. If you are unfamiliar with running boats in marine waters and/or on rivers, it is imperative to inform the crew leader of this and proper training should occur. All personnel must wear a Coast Guard approved life jacket when out on any water. Be conservative and use good judgment: if you think it is dangerous, don't go out on the water.

A boat box equipped with all the necessary tools for the outboard should be in the boat at all times and kept as dry as possible. Necessary tools include pliers, wrenches, screw drivers, spark plugs, spark plug wrench, an extra boat plug, and baling wire. Oars and a bilge pump should also be in the boat. A life jacket is mandatory while operating the boat and handheld VHF and flares should also be carried. In case travel at night becomes necessary, carry a flashlight.

State-owned vehicles will be provided for work purposes and used **only** in the conduct of state business. Use of state-owned property for personal convenience is expressly prohibited. Individuals other than those on official state business shall not be permitted to travel in or operate state owned equipment. An official state credit card will be used to fuel up vehicles. Oil levels in the vehicles should be checked frequently. Use of state-owned vehicle, vessels, and equipment after consuming alcohol is explicitly prohibited.

FIRE AND FIRST AID

All remote employees should have up to date First Aid and CPR certificates. The Nusahgak River drainage is considered remote, therefore; it is required for this project. Make an effort to avoid intestinal parasites such as *Giardia*. When in doubt, boil your drinking water for 15 minutes.

Check your camp's fire extinguishers. Know where it is and how to use it! Inventory your camp first aid kit, replace items as needed and become familiar with basic first aid treatment. Review the first aid booklet.

COMPATIBILITY OF FIELD PERSONNEL

If you find yourself unable to get along with your camp mate, notify your supervisor and an attempt will be made to resolve the situation.